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Monitoring Navigation Using Time-Lapse Video Recorders

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PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) will present the hardware and methodology for monitoring navigation on inland waterways using video cameras and time-lapse video recorders. This method is being used on several projects by ERDC Principal Investigators to record the path, orientation, and speed of tows and ships navigating U.S. inland waterways. This method has proved to be a quick and inexpensive method to document navigation conditions in open river conditions as well as near locks and dams. This CHETN is being published under the Greenville Bendway Weirs work unit of the Monitoring Completed Navigation Projects (MCNP) program.

BACKGROUND: Evaluation of existing navigation conditions is an important part of developing solutions for adverse navigation conditions. Typical methods to evaluate navigation conditions prior to time-lapse video was to either ride the vessel through the reach or observe the path of the vessel from a vantage point such as the locks. Pictures or video recordings were used to document the movements of the vessel through the reach. However, this method provided a limited amount of data, possibly one or two vessels with one flow condition. A time-lapse video system can be installed in the field to record data over an extended period of time that covers a wide range of vessels and navigation conditions. This method provides multiple tow or ship paths with a range of flow conditions that can be used for evaluation of navigation conditions. A system can include multiple cameras that track vessels through extended reaches and can be installed in remote locations and powered by a solar power system.

EQUIPMENT: A basic time-lapse video system consists of a time-lapse video recorder and video camera. The time-lapse video recorder should be similar to the Sony time-lapse video cassette recorder model SVT-S3100. At a minimum, the recorder should be programmable for a daily start and stop time, time-lapse interval, and on-screen display of time and recording interval. The recorder should also have a battery backup for the recorder clock and programming in the event of a power failure. Depending on the site, the recorder may need to be installed in a weatherproof case and mounted outside in the elements. A standard electrical box can be modified to house the time-lapse recorder and other components of the system (Figure 1). The electrical box can be attached to a railing or light standard using a chain mounting system, bolts, or clamps. The

Figure 1. Time-lapse recorder and enclosure

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chain mounting system provides flexibility in attaching the recorder box to poles or rails and has been found to be very useful. The recorder box should allow enough space for the recorder and the power supply for the video camera. Although the recorder specifications states that the recorder was designed to be operated in the horizontal position, experience has shown that the recorder performs satisfactorily in a vertical position (Figure 1). In extreme weather conditions, the recorder box can be outfitted with heat strips and/or a fan to control the temperature inside the box.

A high quality camera should be selected to provide clear, crisp pictures for analyses. The video camera should be similar to the Sony color video camera model SSC-CX34/34P. The SSC-CX34/34P camera is compact, lightweight and has a 12-power zoom lens with automatic iris. A camera without a zoom lens can be used but the zoom lens allows better compositions of the target area without repositioning the camera. The automatic iris is essential for adjusting the iris to changing light conditions in the field. In almost all applications, the camera should be mounted in a weatherproof camera case with a mount that allows some rotation for aligning/positioning the camera (Figure 2). In extreme weather conditions, the camera case can be outfitted with heat strips and/or a fan to control the temperature inside the case. The SSC-CX34/34P camera operates on 24-V AC and therefore requires a transformer, which can be installed in the recorder box.

Figure 2. Weatherproof camera case

In many locations the time-lapse video system can be operated from an existing electrical power source. However, some monitoring plans call for the system to be installed in remote areas without existing electrical power. In those cases a solar power system can be installed to operate the time-lapse video system. A typical solar system consists of solar panels, 12-V batteries, battery regulator/charger and an inverter to convert 12-V DC power to 120-V AC power (Figures 3 and 4). The solar system should be sized based on the latitude of the site, daily recording time and the number of time-lapse video systems operating from the solar system. The Sony time-lapse video system previously described uses approximately 27 W excluding any heat strips or fans. The solar panel manufacturer provides details for computing the number of panels and batteries needed based on the latitude of the site, the number of days of autonomous operation required and the wattage of the equipment. However, experience has shown that a system of solar panel providing 200 to 250 W and two or three 90 amp/hr batteries will provide sufficient power to operate one time-lapse video system approximately 15 hr per day without failure (Figure 4). This system is somewhat less than recommended by the manufacturer of solar panels and should be increased to the manufacturer’s specification if nonfailure of the system is critical. A much larger system would be required if heat strips and/or a fan is used to control the temperature in the cases.

Figure 3. Solar panels

Figure 4. Batteries and regulator/charger

INSTALLATION OF EQUIPMENT: Selection of the installation site for the camera is mostly dictated by the purpose of the monitoring. When monitoring lock approaches, the camera should be mounted so that it is aligned with the guard or guide wall and as high as possible. This location provides the best perspective for analyses of vessels approaching the lock. A video recording does not provide good depth perception; therefore distances along the vertical axis of the camera view can be difficult to measure. The higher the camera view and the closer the perspective is to a plan view, the more accurately distances along the vertical axis of the view can be measured. However, if vessel impact on the wall is being measured, the alignment of the camera should take precedence over the height of the camera. Distances and angles can be accurately measured along the horizontal axis of the camera view.

When monitoring navigation channels, the camera should be aligned with the channel as much as possible. However, a high camera position is preferred over the camera being aligned with the channel (Figure 5). A high camera position tends to allow more accurate measurement of distance and angle.

It is best to locate the time-lapse video recorder near a power source and in an accessible location. The videotapes will need to be changed periodically over an extended period of time; therefore consideration should be given to the ease of access. In some cases the time-lapse video recorder may be located inside an existing structure. The video cable and power cord for the camera can be run several hundred feet if necessary. Care should be taken in routing the cables from the video recorder to the camera to avoid any conflict with normal use of the site.

The standard electrical boxes used to house the time-lapse video recorder can be locked and provides some degree of protection from vandalism or theft. However, in remote areas where additional protection is required, heavier gauge steel boxes can be used to protect the equipment (Figure 6).

DATA COLLECTION: The time-lapse interval for data recording depends on several factors; hours of daily recording, number of days between changing videotapes, and speed of the event being monitored. The SSC-CX34/34P camera has low light capabilities, and with the auto iris lens, can record data in low light conditions. In some cases data can be collected 24 hr a day. However, at most sites useful information is collected during daylight hours, which most of the year can be covered by 15 hr of data collection. The Sony SVT-S3100 time-lapse video recorder can record 168 hr on a standard 120-min videotape at its longest interval setting. When the system is installed at an existing lock and dam or other facility with U.S. Army Corps of Engineers personnel, the videotapes can easily be changed every 7 days and the SVT-S3100 could record data 24 hr a day. However, at some remote sites where changing tapes may be difficult, the SVT-S3100 can be set to record for 12 hr and the videotapes changed every 14 days. There are several models of time-lapse video recorders available that record up to 240 hr on a 120-min videotape. These recorders could provide15 hr of recording per day for 14 days with a safety factor of 2 days in case of delays in changing the tapes. In situations where events such as vessels approaching lock walls are being studied, a faster time-lapse interval should be set.

Figure 5. View from camera mounted on transmission tower

DATA EVALUATION: Evaluation of the time-lapse video data is best performed using a video cassette recorder (VCR) with a toggle wheel advance such as the JVC S4600U rather than a basic VCR. The toggle wheel advance allows the videotape to be advanced one frame at a time for analyses. The videotapes can be used for several types of analyses. The simplest analysis is viewing the path of the vessel as it navigates the reach or approaches the lock under various conditions. Playing the videotape back at normal speeds shows the maneuvering required for the vessel to navigate the reach and allows viewing of many transits in a short period of time. This type of analysis is effective when evaluating outdraft conditions near the upper end of a guard wall or maneuvering required for a tow to enter or leave a lock approach.

Another type of analysis involves developing a grid on the video monitor. Inland waterways barges are a standard length and width for a particular design. The barge design can usually be determined by its shape and the way it fits into the overall tow. Viewing one video frame at a time and using the length and width of a barge, it is possible to develop a grid on a plastic overlay on the video monitor that describes the x and y components of the view on the video monitor. The grid spacing horizontally will be close to uniform, but the grid spacing vertically will decrease significantly from the bottom to the top of the screen. This grid can then be used to measure distance traveled at various points along the vessel's path. Using the elapsed time, a speed can be calculated for the vessel at various positions in its approach. In some cases this same type of analysis can be applied to debris moving in the channel to calculate the velocities of the currents and describe the current patterns. When evaluating tow impact on lock walls, the angle of the tow can be measured from the video monitor, and using the speed of the tow, an impact force on the wall can be calculated.

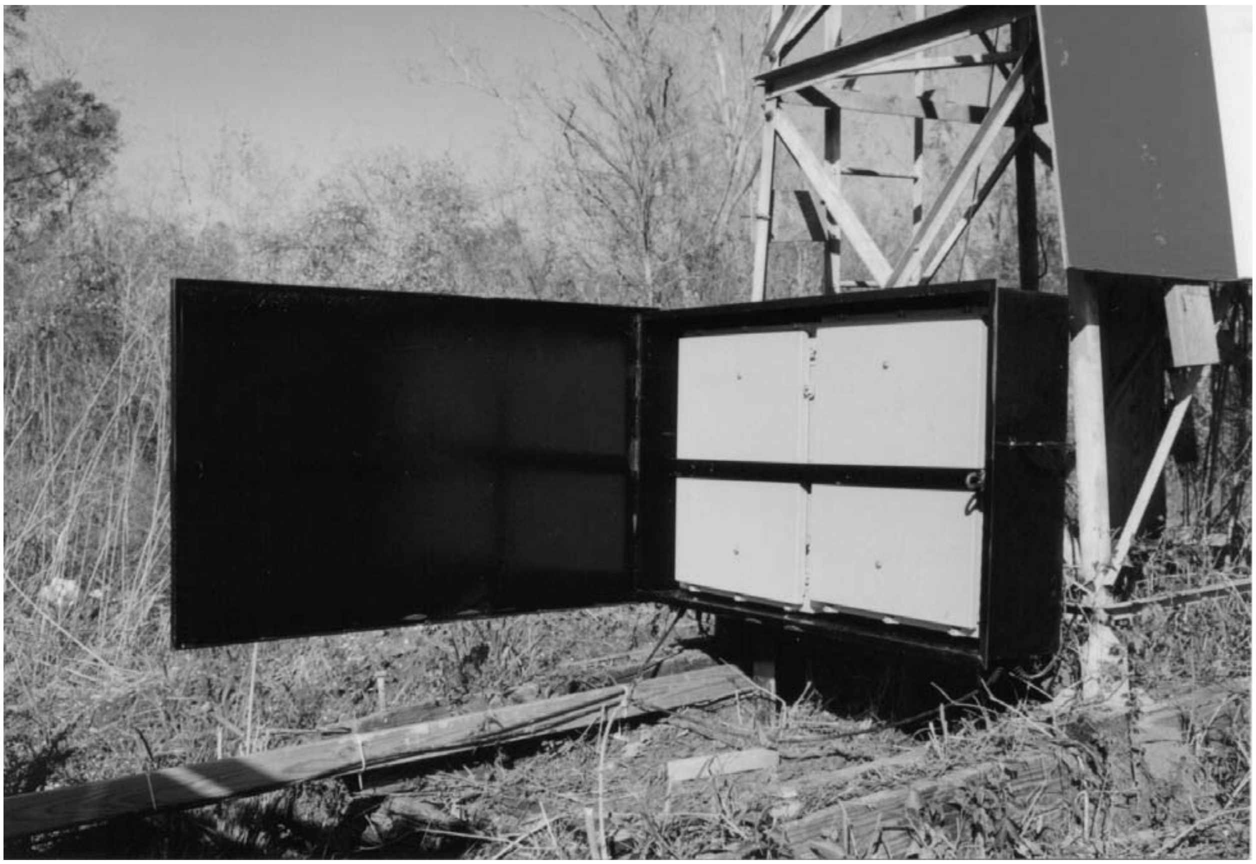

Figure 6. Heavy gauge steel recorder box at remote location

INNOVATIONS IN TIME LAPSE VIDEO CAPTURE: The VCR based systems previously described are based on proven technology and are extremely reliable, robust, and relatively inexpensive to field. Under the Corps' Innovations for Navigations Program, PC-based video capture systems, also referred to as Smart Video Capture (SVC), were developed and have been deployed to monitor barge and vessel traffic at several of the Corps locks. These systems have a number of advantages over conventional time-lapse video which are as follows:

a. Data is intelligently decimated in an automated, unattended manner preserving only the time intervals of interest, thereby reducing processing time.

b. Triggers may be video-based and/or gauge-based and data prior to the trigger may be saved as well as afterwards due to the use of a circular frame buffer.

c. With PC-based video capture, it is relatively easy to overlay important sensor data, such as wind speed and direction, pool level, and other parameters, directly on the video frame.

d. A very important feature of the SVC system is that the software allows the operator to graphically locate up to 10 trigger boxes on the image and to set image-based trigger parameters, such as size of the trigger area, pixel content (red, green, and blue frame-to-frame differences are independently compared to the associated trigger intensity level limit). When these values change by this amount from a selectable previous frame, the system "triggers" and stores to disk.

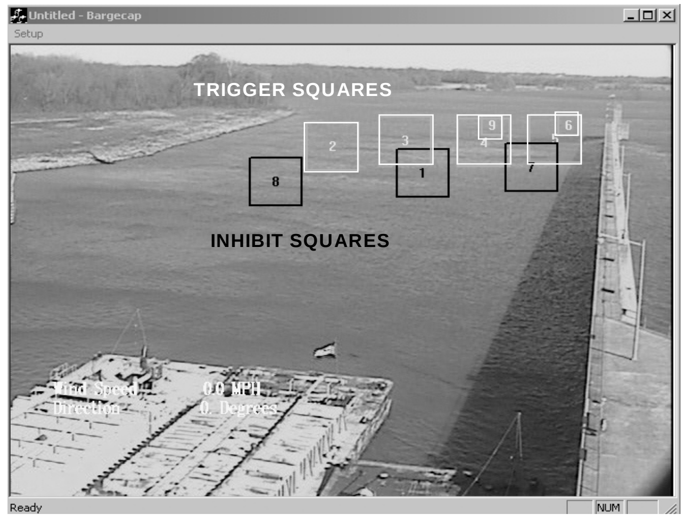

Figure 7. SVC trigger setup from J. T. Myers lock and dam upstream approach

e. Trigger inhibit flags can also be set that operate much like the triggers to block capture for a selected interval of time after the inhibit trigger fires. This feature is useful in lock approach studies to block capture of outbound traffic. The active triggering features, when properly set, greatly reduces the data storage requirements and analysis time.

f. The final advantage with this type system is that, as part of the process, video is captured in digital format, and does not require any post-processing to use with data processing software.

Also developed in tandem with the SVC system was a software tool that allows the user to "pick" points off the captured frame that are referenced to real-world coordinates via camera 2-D to 3-D (fixed elevation-water level) transformations. To accomplish this the exact location of the camera, its field and angle of view, and at least three reference points across the image should be determined. These reference points are usually taken to be at the waterline. Water level, which can be highly variable, is also an input to the program. The software allows the operator to manually track two sets of points (e.g., the front right and rear right corner of the vessel) frame to frame. The coordinates of these points are stored to a data file that can be readily imported into CAD software to display vessel or tow tracks as an overlay to the site drawing. This technique has been used to analyze approach data at J.T. Myers lock and dam. This tool is part of the playback program that has several useful overlays that may be selectively enabled:

a. Data from analog gauges

b. Data from digital gauges

c. Time/date, event count, comments, etc.

d. Track lines selected by mouse clicks on vessel points *e.* Trigger squares (trigger parameters may be input into playback program to test the relative effectiveness of different settings)

Figure 8. Screen capture of SVC player software - from Soo locks

The JPEG images may be played forward or reverse, single frame advanced, and saved as a video MPEG. The MPEG will be created from the current screen images (i.e., whatever overlays are enabled will be saved in the MPEG (playable by Windows Media Player © Microsoft).

While the SVC system has some distinct advantages over the conventional methods it is not without its drawbacks. The active triggering compares pixel content in the trigger squares to a previous frame (selectable 1-10 frames previous). Changes in lighting caused by cloud cover or wind on the water can cause false triggers. These can be minimized through optimization of the trigger parameters. Conversely, if trigger parameters are too tightly set, the target may move through the frame without inducing a trigger event.

Data management can also be an issue. Unlike the videotapes that are relatively inexpensive and can be stored indefinitely until needed, SVC data are usually stored on a removable 100-GB hard drive. Depending on frame rate and activity these can collect data for two months or longer. Once exchanged, the hard disk should be downloaded and processed quickly so it can be recycled to the field. Long-term data storage is currently being done on DVD media.

Cost for these systems is also a factor. The equipment and configuration cost for an SVC system is about twice that of the VCR solution. However, reduced processing time and rapid data integration will in many cases offset this initial cost.

SUMMARY: Time-lapse video monitoring is being used on numerous projects by ERDC Principal Investigators to record the path, orientation, and speed of tows and ships navigating U.S.

inland waterways. This method has proven to be an effective and efficient means of monitoring navigation in both open river conditions and near locks and dams. The technique is relatively low cost and provides relatively accurate results.

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